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ABSTRACT

The dialogue in this module (about a nuclear power plant in Morong, Bataan) is designed to help students answer these questions: (1) When did the construction of the plant begin? What delayed the construction? (2) How does a nuclear power plant produce electricity? What are the nuclear reactions involved? (3) How does a nuclear power plant control the nuclear reactions? (4) What are some safeguards in constructing a nuclear plant? (5) What are the benefits of having a nuclear plant? (6) How will the costs and dangers of a nuclear plant compare with electric plants using oil or coal? and (7) How does a nuclear plant affect the Philippine economic situation and relationship with foreign groups. It is intended to reinforce and supplement a lesson titled, "A Visit to a Nuclear Power Station" in the High School Science IV, "Physics in Your Environment." Brief comments for students and for teachers (with suggested instructional strategies) are included. (JN)

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What We Make

SE 046 265

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Science and Technology Education in Philippine Society

Cover Photo: PHILIPPINE NUCLEAR POWER PLANT
Morong, Bataan

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GO NUCLEAR?

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GO NUCLEAR?

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CREDITS

Figures 1 and 4 – Philippine Atomic Energy Commission
Cover photo and Figure 3 – National Power Corporation
Figure 2 – United States Atomic Energy Commission (Reference 7)

TO THE READER

Perhaps you have heard or read about the nuclear power plant in Bataan which has attracted public attention and concern. The dialogue presented here aims to give some facts, explain some issues and science concepts about the nuclear plant, and encourage further reading. It is hoped that with greater understanding will come informed opinions and better decisions.

After reading the dialogue, it will be interesting to find out for yourself how well you can answer the following questions:

1. When did the construction of the plant begin? What delayed the construction?
2. How does a nuclear plant produce electricity? What are the nuclear reactions involved?
3. How does a nuclear plant control the nuclear reactions?
4. What are some safeguards in constructing a nuclear plant?
5. What are the benefits of having a nuclear plant?
6. How will you compare the costs and dangers of a nuclear plant with those of electric plants using oil or coal?
7. How does a nuclear plant affect our economic situation and relationship with foreign groups?

While reading the dialogue, it is helpful to list the benefits of a nuclear plant on one hand and the costs and dangers on the other. Add to the list using other sources of information. Compare the benefits, costs, and dangers. Finally, ask yourself: If I were in a position to make decisions about the plant, would I recommend the construction of another nuclear plant? Why?

For more information and explanation about the nuclear plant, read the sequel of this dialogue, *Nuclear Power: Pros and Cons.*

TO THE TEACHER

This dialogue is intended to reinforce and supplement Lesson 12.3, A Visit to a Nuclear Power Station, in High School Science IV, *Physics In Your Environment.* The dialogue is best presented after the lesson.

For classroom use, it is suggested that selected students read the lines of the five characters in the dialogue. Instruct these students to take on their roles seriously and to read their lines with feeling to sustain the interest of the class. The diagrams in the dialogue can be enlarged and redrawn on charts or on the blackboard.

While the dialogue is being presented, remind the other students to list the advantages and disadvantages of a nuclear power plant. These can be pooled and written later on the blackboard. Students could add to the list from their other readings. This dialogue is meant to stimulate further discussion among the students.

The list of advantages and disadvantages, rather than the teacher's own opinion, should serve as the basis for students' evaluation of the nuclear plant. The students could be asked, for instance, whether or not they favor the construction of another plant and to give their reasons. Encourage as many students as possible to individually express their views to develop their communication skills.

It is important to tell and show the students that for a controversial topic like the Bataan nuclear plant, an objective comparison of the pros and cons and gathering as many data as possible before forming opinions, conclusions or decisions are advisable and in keeping with the scientific method. The reliability of the sources of data should also be considered.

Modify the script to update the data, make the presentation more interesting, or to make it more suited to your classroom conditions. For example, the merienda called for in the dialogue could be dispensed with.

The data in the dialogue were the latest available at the time the module was written. For continuous updating of data, collect news clippings and magazine articles about the nuclear plant. For additional information, write to: The Commissioner, Philippine Atomic Energy Commission, Don Mariano Marcos Avenue, Diliman, Quezon City.

Go Nuclear?

One hot afternoon, Felipe and his wife, Mila, invited their friends, Celso and Delia, to merienda. Felipe, Celso, and Delia share a common interest, the nuclear power plant in Napot Point, Morong, Bataan. Felipe reads the newspapers to know the latest news about the plant. Celso works in a nuclear reactor and Delia is concerned about the environment.

Mila had already laid the food on the dining room table when another one of those brownouts struck. With the electric fans off, Mila decided to serve merienda in their yard under the shade of a tree. While eating, Felipe, Celso, and Delia had a very interesting conversation.

Felipe : I am sorry about this brownout. Are you comfortable?

Celso : Do not worry. The heat does not really bother us. We only have to wait a little more time until our nuclear power plant is operational. It is just too bad its construction was delayed. With an additional power plant, the number of power failures here in Luzon could have been decreased.

Delia : Many people are protesting the construction of the plant. If you ask me, they have the right to say publicly what they feel about a project that affects them.

Felipe : If I remember correctly, the first study on a nuclear plant for the Philippines was made way back in the 1960's. In 1973, when we were hit by the oil crisis, the decision had already been made to construct a nuclear power plant. The contract was finalized in 1976, and construction began the following year.

Ben (taking a seat): Father, may I join you? I hear you talking about the nuclear plant.

Felipe (smiling): Certainly. This is Ben. He is very much interested in nuclear engineering.

Delia : Ben, your father was saying that construction of our nuclear plant began in 1977. In June 1979, the President of the Philippines stopped the construction and formed a group to review the safety of the plant. Public hearings were conducted. In September 1980, construction continued with the agreement that additional safety features will be put into the plant.

(Mila enters, bringing more food.)

Mila (takes a seat and serves the food): What is this nuclear plant you are talking about? How does it operate? Why are many people against it? Why is the government constructing it?

Ben : We learned in school, Mother, that a nuclear power plant produces electricity.

Mila : How does it produce the electricity, Son?

Ben : I will just get my school project, Mother, so I can explain the plant better. (Ben leaves.)

Felipe : The nuclear power plant is an alternate energy source. It does not use oil to produce electricity.

Celso : When the plant is in commercial operation in 1985, it will supply 16% of the electric energy requirements of Luzon and 5% of the energy requirements of the country.

Mila : Then why are some people against it?

Delia : For safety, economic and political reasons. Some people still remember the atomic bomb dropped in Hiroshima and Nagasaki in Japan in 1945. Large amounts of nuclear energy were released. Many Japanese died and hundreds suffered from burns, birth defects, and diseases like leukemia, cancer, sterility as a result of the radiations. Some are still suffering from the effects of the radiations up to this time.

Celso : Despite what happened to Japan, it has 25 nuclear power plants in operation as of 1982. Nuclear energy has many uses in medicine, agriculture and industry. For example, radiation is used for treating cancer. While too much radiation may lead to cancer, controlled amounts of radiation can destroy cancerous cells. Another example is the use of radiation to delay ripening of fruits, to speed up the growth of rice, the so-called atomic rice, and to produce new varieties of crops resistant to common agricultural diseases.

Delia : The use of radiation can be limited to medicine, agriculture and industry where I think the dangers of radiation are less.

(Ben comes back bringing two charts, blackboard and chalk.)

Ben : Mother, look at my project. This chart (referring to Fig. 1) shows how a nuclear plant produces electricity. Stages 2 to 6 are the same as in many electric power plants using oil. The main difference, Mother, is that in a nuclear power plant, nuclear reactions produce the heat.

Felipe : What are these nuclear reactions? How is the heat produced?

Ben : We also learned in school that these nuclear reactions are called nuclear fission and chain reaction. This other chart (referring to Fig. 2) shows an example of nuclear fission. A moving neutron hits a big nucleus like uranium-235 and splits it mostly into two different medium-sized nuclei, in this case, barium and krypton. Neutrons, radiations and heat are given off in the process.

Mila : What are neutrons? Is uranium-235 used in a nuclear plant?

Celso : Neutrons are particles from the nucleus of an atom. The fuel to be used in our nuclear power plant is natural ura-

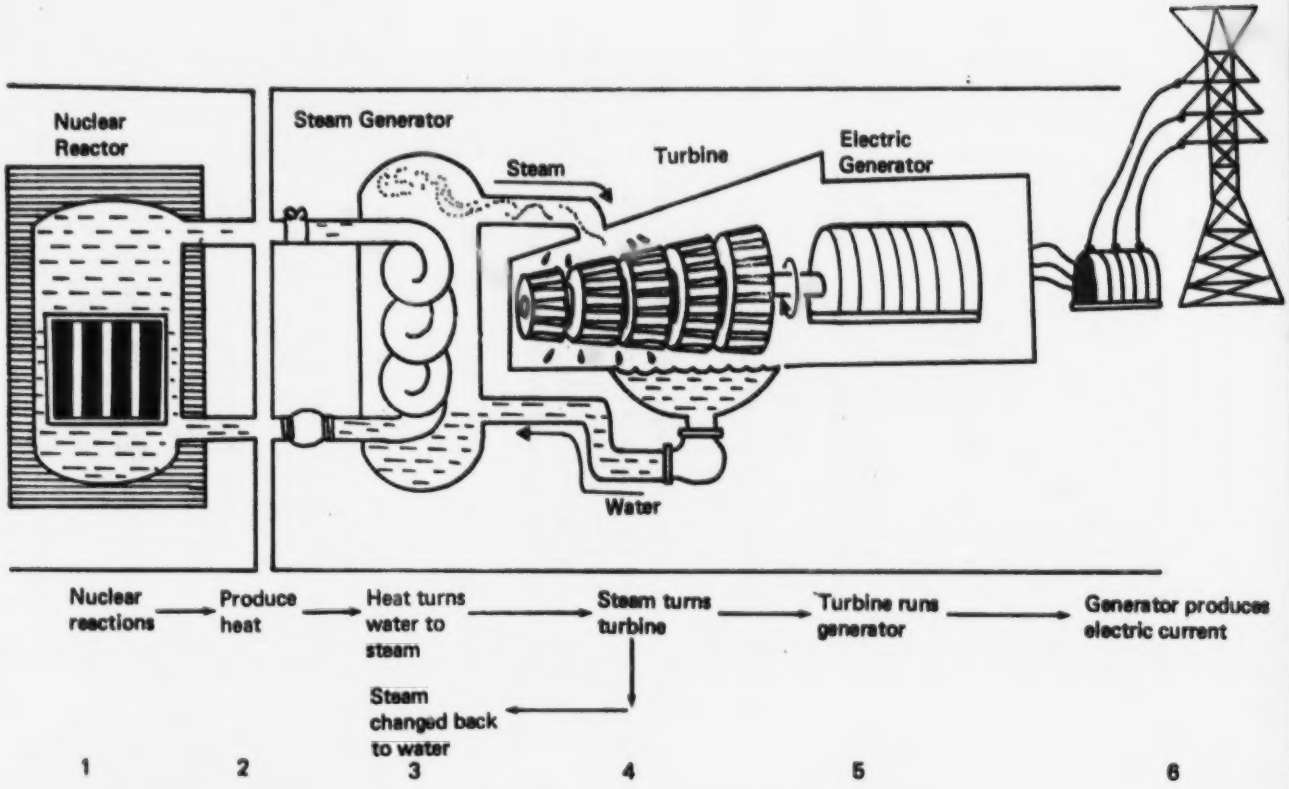

Fig. 1. The Production of Electricity by a Nuclear Power Plant

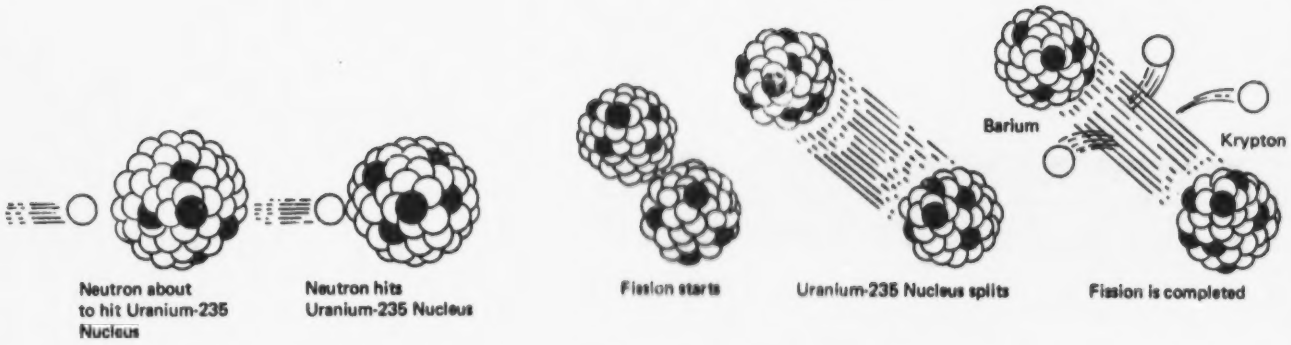

Fig. 2. An Example of Nuclear Fission

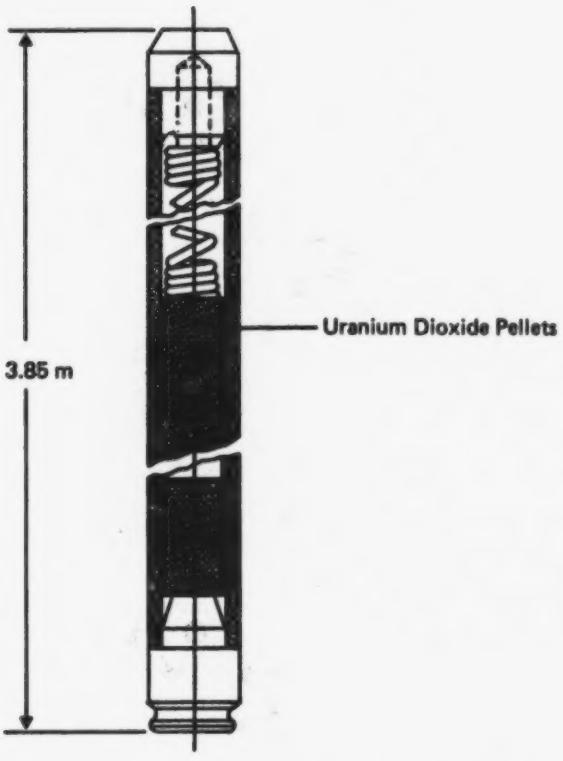

Fig. 3. Diagram of a Fuel Rod of the Bataan Nuclear Plant

nium enriched with around 3% uranium-235. Natural uranium has only 0.7% uranium-235. The fuel in the form of ceramic pellets is placed inside rods. (Celso draws Fig. 3 on the blackboard.)

You learned your lesson well, Ben. Some of the neutrons given off in a nuclear fission hit and split other uranium nuclei, forming more neutrons and giving off more heat. This series or chain of nuclear fissions is called chain reaction. These reactions are contained within the tightly sealed fuel rods.

Felipe : What happens if the chain reaction goes on and on, and more and more heat is produced? Will the plant explode like an atomic bomb?

Celso : Certainly not. This does not happen in a nuclear power plant where chain reaction is controlled. Besides, the percentage of uranium-235 in the fuel is too small to cause atomic explosion. At most what can happen is the melting of the core of the plant because of too much heat. Remember, the nuclear reactions take place in the core. But the possibility of the core melting is very small.

Delia (stands up): That does not make it less dangerous. When the core melts, radiations may escape into the atmosphere and surrounding water. People living nearby including animals will be breathing in the radiations. The temperature of bodies of water nearby will rise and may kill the plants and animals living in the water. We cannot let these happen.

Celso : The plant has built-in safety features to prevent an accident or minimize the effects of an accident. During normal operations of the plant, the radiations released to the environment are even less than the increase in natural radiations as one goes from Bataan to Baguio City. Higher places have higher natural radiations coming from the sun and outer space.

As for the temperature increase, some fishes prefer higher temperature, while others will simply move away.

Ben : What are the safety features of the plant? I only know what we learned in school. The core of the plant has three thick walls made of concrete and steel to prevent radiations from escaping. (Celso draws Fig. 4 on the blackboard.) The plant must be at least one kilometer away from houses or buildings. Also, the plant must be safe from earthquakes, typhoons, or floods.

Delia (sits down): The plant is just 9 kilometers from Mt. Natib, a volcano which may still erupt even though it has been inactive for thousands of years. One fault is 30 km from the site and another is 100 km away.

Celso : All these were considered and the location would not have been approved if the danger were great. In addition

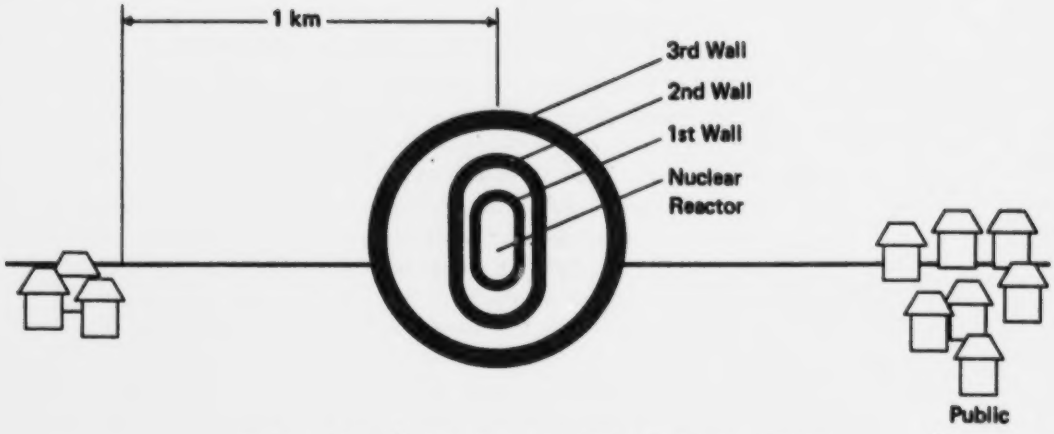

Fig. 4. Diagram of the Protective Walls of a Nuclear Reactor

to the safety features mentioned by Ben, the core of the plant has built-in ways of controlling chain reaction. The fuel of the plant is placed in rods. In between the fuel rods are the control rods. The control rods absorb the neutrons produced by the fission processes.

Mila : What are the control rods made of?

Celso : The control rods in our power plant are made of hafnium, a metallic chemical element. The number of control rods inserted and the depth of insertion determine the number of neutrons available for fission. This also determines the power level of the plant at a given time.

Felipe : But the power level of the Bataan nuclear plant at any time will not be greater than 620 million watts, its electric power capacity.

Celso : That is right.

Mila : In case of emergency, is it possible to shut down the plant completely?

Celso : Yes. Control rods are used for a fast shutdown if necessary.

Delia : But radiations can still be released to the environment even after a shutdown.

Felipe : I understand that as a result of the public hearings, the design of the Bataan plant was updated and now has more safety features.

Delia : That does not reduce the possibility of an accident to zero. Besides, there is still the problem of what to do with nuclear waste.

Mila : Why worry about the nuclear waste? Can we not dispose of it just like any other waste?

Delia : Nuclear waste still gives off radiations. Some radiations are short-lived but others take thousands of years to decay. Celso, how will our nuclear wastes be stored?

Celso (stands up): Waste disposal is also the concern of other nuclear plants worldwide. Some scientists and engineers are continuously researching on safer ways of storing nuclear waste. In our case, the solid wastes like contaminated clothing and reactor equipment will be mixed with cement and placed in sealed drums. These will be stored in a radioactive waste disposal area which is still under study.

Delia : Present ways of handling and storing nuclear waste are not 100% safe. We cannot also totally avoid nuclear accidents, natural calamities or destruction of the plant by enemies of the government.

Celso : The possibility of a nuclear accident cannot be reduced to zero, but the possibility is very low. Studies in the United States show that deaths and injuries from power plants

using coal and oil are a lot more than those from a nuclear plant. Deaths from accidents, for example, with motor vehicles are even much greater than from electric power plants. Yet we continue to use vehicles daily. In spite of the low possibility of a nuclear accident, there are emergency plans prepared for the safety of the people around the plant.

Delia : Even if the chances of death and injuries from a nuclear plant are a lot less, when these happen, the results are terrible for man, animals and plants. The effects can be long lasting. Besides, we have other alternate energy sources that we can develop such as geothermal and hydroelectric energy, and energy from wood.

Celso : Other alternate energy sources also have their harmful effects to the environment.

Felipe : It is a matter then of choosing the energy sources which give the greatest benefit with the least harm or cost.

Ben : I learned that a nuclear plant produces electricity at a cost less than that in an electric plant using oil or coal.

Celso (sits down): That is right. For the same power capacity, the Bataan nuclear plant will generate electricity at a cost 75% that of an oil-fired plant and 95% that of a coal-fired plant. One uranium fuel pellet which is 1.35 cm long with an outside diameter of 0.82 cm has an energy equivalent to 3 barrels of oil, 1 ton of coal, or 2 1/2 tons of wood.

Felipe : You are talking of the operating cost. How about the cost of building the plant? I read in the papers that the addition of several safety features increased the cost of the plant. The present cost is close to two billion dollars.

Mila : That is a lot of money by our standards. With that money, we can provide food, health care, shelter, and education for millions of poor Filipinos.

Delia : That is not all. To build the plant, we had to borrow heavily from foreign banks like the United States Export-Import Bank.

Celso : For one thing, the power plant will save the country about 215 million dollars a year, just for not importing oil equivalent to what will be consumed by a 620 million watt oil-fired plant.

Ben : Do we have to spend, too, on uranium for the fuel?

Celso : Yes. The United States will supply us with the initial uranium we need, as part of the loan.

Delia : The loans and imported uranium make us dependent on foreign countries, on the banks for the loans and on the countries selling uranium.

Felipe : I understand Westinghouse International Projects Company is building our plant, supplying the parts and services.

Celso : That is correct.

Delia : This means that we will be dependent, too, on a foreign company for parts and services.

Celso : For parts, yes, but not necessarily on services. We have several engineers now who have gone abroad for training on nuclear reactor operations. Construction of the nuclear plant provided jobs and advanced training to many Filipinos.

Delia : How about the farmers and fishermen who were dislocated from their lands and fishing grounds to give way to the plant? How about the possible dangers to the air, land, water and living things in Bataan near the plant? How about our economic and technological dependence on foreign groups? Are the benefits of the plant worth all these?

Celso : Yes. I believe so. There were only a few farmers and fishermen affected. The dangers you are afraid of are minimal and well under control. The National Power Corporation which will operate the plant will continously monitor the effects of its operations on the environment. The Philippine Atomic Energy Commission regulates and licenses the construction and operations of the plant. As for economic dependence, we estimate that the plant will pay for itself during its 30-40 years of operation.

Ben (looking back at the house): Father, the electricity is back!

Mila : I wonder if that is a signal of hope for our nuclear power problems.

Felipe : Let us go back inside the house and continue our interesting discussion.

(Everyone stands to leave. Felipe puts his arms around Ben.)

Felipe : Son, if you become a nuclear engineer, maybe you, together with other engineers and scientists, can help solve some of our nuclear power problems.

(Father and son smile at each other.)

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